CAUCASIANA
Journal on the biodiversity of the Caucasus and the adjacent regions

Caucasiana 5: 1–14 (2026)
DOI: 10.3897/caucasiana.5.e169526

Research Article

Succession of soil microarthropods during leaf litter decomposition in two contrasting broadleaved tree stands: A litterbag study

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Abstract

Here, we present the results of a litterbag experiment performed in a natural broadleaved forest to study the patterns of microarthropod succession in decomposing litter and the level of adaptation to local vs. spatially distant microhabitats. Ten oak and ten beech leaf-filled, defaunated litterbags were placed under an oak tree, and the same were placed under a beech tree (forty litterbags in total). Five litterbags of each type were collected six and twelve months after the beginning of the experiment, in June and December, respectively.

Microarthropod fauna differed between the two sampling events, showing higher diversity and abundance in winter, reflecting the progress of colonization. Microarthropod faunal abundance and species numbers in litterbags filled with oak leaves and placed under the oak trees were significantly higher than those in the other types of litterbags, suggesting the adaptation of the local microarthropod community to this type of litter. The trophic composition of microarthropods showed a higher diversity at the end of the experiment, with increased ratios of predatory and fungivorous taxa, indicating more diverse and easily accessible food resources. Litter dry mass declined continuously for beech litter, while the rate of decline slowed in oak litter between the first and the second sampling events, probably due to the more robust structure of oak leaves compared to beech.

Key words: decomposition, feeding mode, litterbag, Mesostigmata, Oribatida, soil microarthropods

OPEN ACCESS

Academic editor: Levan Mumladze
Received: 22 August 2025
Accepted: 26 November 2025
Published: 1 April 2026

ZooBank: https://zoobank.org/2DE70D64-52ED-4F49-B52B-026C4A4DDAA0

Citation: Murvanidze M, Abuladze M (2025) Succession of soil microarthropods during leaf litter decomposition in two contrasting broadleaved tree stands: A litterbag study. Caucasiana 5: 1–14. https://doi.org/10.3897/caucasiana.5.e169526

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Introduction

Soil represents a thin crust over the Earth created by the combined influence of abiotic (topography, climate, parent materials) and biotic (soil organisms) interactions (https://www.fao.org/soils-portal). A major contributor to the soil's organic content is leaf litter, which plays a crucial role in the carbon cycle during the process of decomposition (Schmidt et al. 2011). Soil mesofauna, particularly soil microarthropods, are dominant inhabitants of soil systems and are found in all soil types. They have a significant impact on decomposition processes and, through various trophic interactions, create linkages in soil food webs (Coleman et al. 2017).

Microarthropods promote litter decomposition either by direct consumption or by the stimulation of microbial activity (Fujii and Takeda 2017). Dominant representatives of soil microarthropods are oribatid mites, which feed on a wide range of resources, including dead organic matter, lichens, fungi, algae, bacteria, and nematodes (Maraun et al. 2011, 2020). Recent studies also indicate that they show trophic plasticity by adjusting their diet to the specific type of food available, allowing them to occupy different types of habitats and ecosystems (Maraun et al. 2020).

While the fact that soil microarthropods show adaptations to their local environment is well documented (Menta et al. 2014, 2018), less information is available on how fast they start to colonize new microhabitats and utilize resources that are different from those they are already adapted to in their previous habitat. To fill this knowledge gap, we conducted an experiment with the aim to study the process of succession of microarthropods in defaunated litterbags filled with locally available leaves and those filled with leaf litter from a different location where the dominant tree habitat was different.

Specifically, we tested the patterns of colonization of soil microarthropods in litterbags filled with oak or beech leaves placed in stands of oak and beech trees. We hypothesized that the fauna would colonize leaves of the local dominant tree type faster; as a result, the rate of decay of oak leaves placed in a beech stand would be less rapid compared to the decay of oak leaves under a stand of oak, and vice versa. During the process of litter decomposition, different feeding resources become available to microarthropods, with fungi appearing within the first few days (Osono 2007) followed by bacteria (Aneja et al. 2006; Bray et al. 2012; Osono 2007). This should lead to changes in the microarthropod trophic composition during the progress of litter decay, regardless of local or distant microhabitats. We predicted that in the early stage of decomposition, the fauna would be dominated by primary decomposers, while by the end of the experiment, the share of fungal feeders and predators would have increased.

Material and methods

Experimental setup

The experiment was carried out in a natural, relatively undisturbed broadleaved oak-hornbeam forest with beech tree (*Fagus orientalis*) stands at the upper edge of the forest slope. Two plots were selected at 900 m a.s.l. (N41.8604717, E44.9047908) and 1,100 m a.s.l. (N41.8695224, E44.9207931), with the former dominated by oak (*Quercus iberica*) and the latter by beech (*F. orientalis*) trees. In November 2023, the leaves of oak and beech trees were collected directly from the trees to avoid contact with the ground and contamination with existing soil fauna. These leaves were taken to the laboratory and dried in an oven at 70°C for 24 hours.

Forty litterbags, measuring 15 × 15 cm, were made of insect-protective mesh with a mesh size of 2 mm. The leaves were weighed on a scale to ensure that the initial mass of all litterbags was equal (9±1 g). Twenty litterbags con-

tained only oak leaves, and twenty contained only beech. To avoid mixing up the litterbags, each was assigned a unique marker. The litterbags were taken back to the forest; ten containing oak and ten containing beech leaves were placed under an oak tree in the oak-dominated plot (900 m a.s.l.). Similarly, ten oak and ten beech-filled litterbags were placed under a beech tree within the beech-dominated plot (1,100 m a.s.l.). The litterbags were covered with fallen leaves to avoid accidental human interference.

In June 2024, six months after their initial placement, five litterbags with oak and five with beech leaves were collected from both plots, placed in separate plastic bags, and taken to the laboratory. The same procedure was repeated in December 2024, twelve months after the start of the experiment, at which point all remaining litterbags were collected and the experiment was terminated. The acronyms used throughout the study are as follows: QQ – oak leaves under oak; QF – beech leaves under oak; FF – beech leaves under beech; and FQ – oak leaves under beech.

Laboratory treatment

The samples collected at both six and twelve months were subjected to the same laboratory procedure: litterbags were placed in modified Berlese funnels, and microarthropods were extracted for one week, with the extracted individuals stored in 95% alcohol. After the microarthropod extraction was completed, the litterbags were cut open and the litter was dried in an oven at 70°C for 24 hours before being weighed to determine the loss of mass after six and twelve months, respectively.

For the identification of oribatid and mesostigmatid mites, temporary slides were prepared using lactic acid. Identification of adult Oribatida was carried out using the keys from Ghilarov and Krivolutsky (1975) and Weigmann (2006). Identification of mesostigmatid mites was conducted following Ghilarov and Bregetova (1977) and Karg (1993). For Collembola, Chilopoda, and Diplopoda, the number of individuals was counted without species identification. The feeding mode of the microarthropods collected was assigned using Maraun et al. (2023).

Data analyses

Simpson's diversity index (1-D), dominance, and evenness were calculated using the PAST program. A cluster of faunal similarity was created based on the Simpson similarity index. The effects of time—expressed by season (summer or winter 2024)—habitat (under oak or beech trees), and leaf type (oak or beech leaves) were analyzed using a linear mixed-effects model with the litterbag number as a random factor and Habitat, Season, and Leaf type as fixed effects. This was performed using the lmer function of the lme4 package in the R statistical software (R Core Team 2022). Data on microarthropod density and species richness were log-transformed before analysis to improve the homogeneity of variances. A Kruskal-Wallis test was performed to analyze the significance of the difference in leaf mass in litterbags from the start of the experiment compared to the first and second sampling events.

Results

Overview of microarthropod biodiversity in litterbags

During our investigation, 1,785 individual microarthropods were found; 59 species of oribatid mites and 11 species of mesostigmatid mites were identified (Table 1). *Ceratoppia bipilis* was the only species found in all studied microhabitats. Other frequently encountered species were *Achipteria nitens*, *Minunthozetes pseudofusiger*, and *Steganacarus carinatus*. Collembolans were present in all microhabitats. After the first sampling event in June, 44 species were identified; by the end of the experiment in December, 57 species were recorded (Table 1).

The majority of the identified species did not show a preference for habitat placement (oak vs. beech stands). However, *Carabodes dubius*, *C. willmanni*, *Lepidozetes singularis*, and *Phauloppia rauschenensis* were found only under oak stands, while *Carabodes femoralis*, *Damaeolus asperatus*, *D. ornatissimus*, *Liochthonius alpestris*, *Porobelba spinosa*, and *Suctobelba alvateri* were found only in litterbags placed under beech trees. Furthermore, *Gymnodamaeus bicostatus*, *L. singularis*, and *P. rauschenensis* were recorded only in June, while *Eremaeus hepaticus*, *Eubelba dubinini*, *L. alpestris*, *Phthiracarus lentulus*, *Ph. longulus*, and *Suctobelbella duplex* were recorded only in December. Mesostigmatid mite species, such as *Discourella* sp. and *Trachytes arcuatus*, were also found only in December across all litterbag types regardless of placement (Table 1).

Table 1. List of microarthropods in litterbags with different litter type with cumulated number of individuals found in five litterbags of each type (explanations to the acronyms see in methodology section).

Species	QQ - S	QF - S	FQ - S	FF - S	QQ - W	QF - W	FQ - W	FF - W
Achipteria nitens	4	0	6	5	7	1	2	9
Acrotritia ardua	0	0	1	0	0	0	0	0
Amerus polonicus	0	0	1	0	0	0	0	0
Berniniella bicarinata	0	0	0	0	0	1	0	0
Carabodes dubius	1	0	0	0	0	2	0	0
Carabodes femoralis	0	0	1	0	0	0	1	2
Carabodes rugosior	15	0	0	0	0	3	4	1
Carabodes willmanni	1	0	0	0	2	1	0	0
Cepheus dentatus	3	1	6	0	0	0	0	4
Ceratoppia bipilis	10	7	15	1	4	4	11	2
Conchogneta traegardhi	0	0	0	0	0	0	1	0
Cymbaeremaeus cymba	0	0	0	0	0	1	0	0
Damaeus gracilipes	4	1	5	0	0	1	10	3
Damaeolus asperatus	0	0	0	0	0	0	1	1
Damaeolus ornatissimus	0	0	0	0	0	0	0	2
Dometorina plantivaga	0	0	0	0	0	1	0	0
Dorycranosus acutus	1	0	0	0	0	5	0	0
Dorycranosus splendens	0	0	1	2	0	3	0	0
Epidamaeus setiger	0	0	0	0	0	1	0	0
Eremaeus hepaticus	0	0	0	0	2	7	3	5
Eubelba dubinini	0	1	0	0	2	6	22	4
Eupterotegaeus ornatissimus	16	1	13	0	0	2	68	2

Species	QQ - S	QF - S	FQ - S	FF - S	QQ - W	QF - W	FQ - W	FF - W
Gymnodamaeus bicostatus	1	0	4	7	0	0	0	0
Haplozetes elegans	0	0	0	1	0	0	0	0
Hermanniella dolosa	2	0	1	0	0	0	0	1
Hoplophthiracarus illinoisensis	0	0	0	0	2	0	1	1
Hypocepheus mirabilis	4	0	0	0	4	3	2	0
Lepidozetes singularis	1	11	0	0	0	0	0	0
Liacarus coracinus	2	0	1	3	0	2	1	1
Liacarus tubifer	0	0	0	0	0	3	0	1
Licnodamaeus pulcherrimus	0	0	0	6	0	0	0	0
Liochthonius alpestris	0	0	0	0	0	0	8	15
Minunthozetes pseudofusiger	10	0	23	28	4	9	52	31
Mycobates parmaliae	1	0	0	0	0	1	1	0
Oppiella acuminata	2	0	5	0	0	3	2	0
Oribatella berlesei	1	1	0	0	0	0	1	0
Oribatula tibialis	1	0	2	7	0	6	0	0
Oribotritia berlesei	1	0	0	0	0	0	0	0
Oxyoppioides decipiens	0	0	0	2	0	0	0	0
Parachipteria fanzagoi	0	0	0	0	0	0	0	1
Parachipteria georgica	1	0	2	3	1	1	3	13
Phauloppia rauschensis	1	1	0	0	0	0	0	0
Phthiracarus ferrugineus	0	0	0	0	0	0	0	1
Phthiracarus lentulus	0	0	0	0	0	0	3	2
Phthiracarus longulus	6	0	0	0	7	10	6	1
Porobelba spinosa	0	0	3	1	0	0	0	0
Protoribates capucinus	2	0	0	1	0	0	0	0
Ramusella clavipectinata	1	0	3	3	0	1	0	0
Ramusella insculpta	0	0	0	1	0	0	0	1
Scarabacarus longisensillus	1	0	0	0	0	0	0	0
Steganacarus carinatus	2	2	3	3	2	3	4	0
Steganacarus magnus	2	0	2	2	0	3	1	0
Steganacarus ochraceus	0	0	0	0	0	0	0	1
Suctobelba alvateri	0	0	0	1	1	0	1	4
Suctobelbella duplex	0	0	0	0	0	4	3	17
Suctobelbella forsslundi	0	0	0	0	0	0	1	0
Tectocepheus punctulatus	0	0	0	0	0	5	0	0
Tectocepheus velatus	0	0	0	0	0	2	1	0
Xenillus ibericus	0	0	0	0	0	1	0	1
Xenillus tegeocranus	0	0	0	1	0	3	0	2
Amblyseius messor	1	0	0	0	1	1	0	0
Gaeolaelaps aculeifer	1	0	0	0	0	0	0	0
Lasioseius lawrencei	0	0	1	0	0	0	0	0
Leptogamasus obesus	0	0	0	0	0	1	0	0
Pachyseius angustiventris	0	0	0	0	0	0	2	2
Pergamasus crassipes	1	0	2	0	2	8	2	1
Pergamasus barbarus	0	0	0	0	0	1	0	0
Veigaia cervus	0	0	0	0	0	1	0	0
Zerkonidae	3	0	0	1	0	6	1	0
Discourella sp.	0	0	0	0	0	10	99	2
Trachytes arcuatus	0	0	0	0	2	28	50	25
Uropodina	2	0	7	0	2	12	9	6
Collembola	14	10	7	11	52	341	133	88
Chilopoda	0	0	0	0	0	0	1	3
Diplopoda	2	0	0	0	0	2	0	0
Pseudoscorpions	0	0	0	0	1	1	0	0

Simpson's diversity index (1-D) in June was highest in QQ (92%), FQ (90%), and FF (86%) with considerably high evenness. In December, overall biodiversity indices increased, with the highest indices recorded in FQ (94%) and FF (91%), although the evenness was notably lower (Table 2). Cluster analysis of faunal similarity showed a clearer grouping of soil arthropods by season rather than by leaf type. Within each season, higher similarity was recorded between the microarthropod fauna in litterbags placed under oak trees, while microarthropods in FF showed the lowest similarity with other litterbag types in both summer and winter (Fig. 1).

Microarthropod abundance in litterbags

The average number of individual microarthropods per litterbag was higher under the beech trees (53 ± 42 individuals/litterbag) than under the oak (44 ± 39

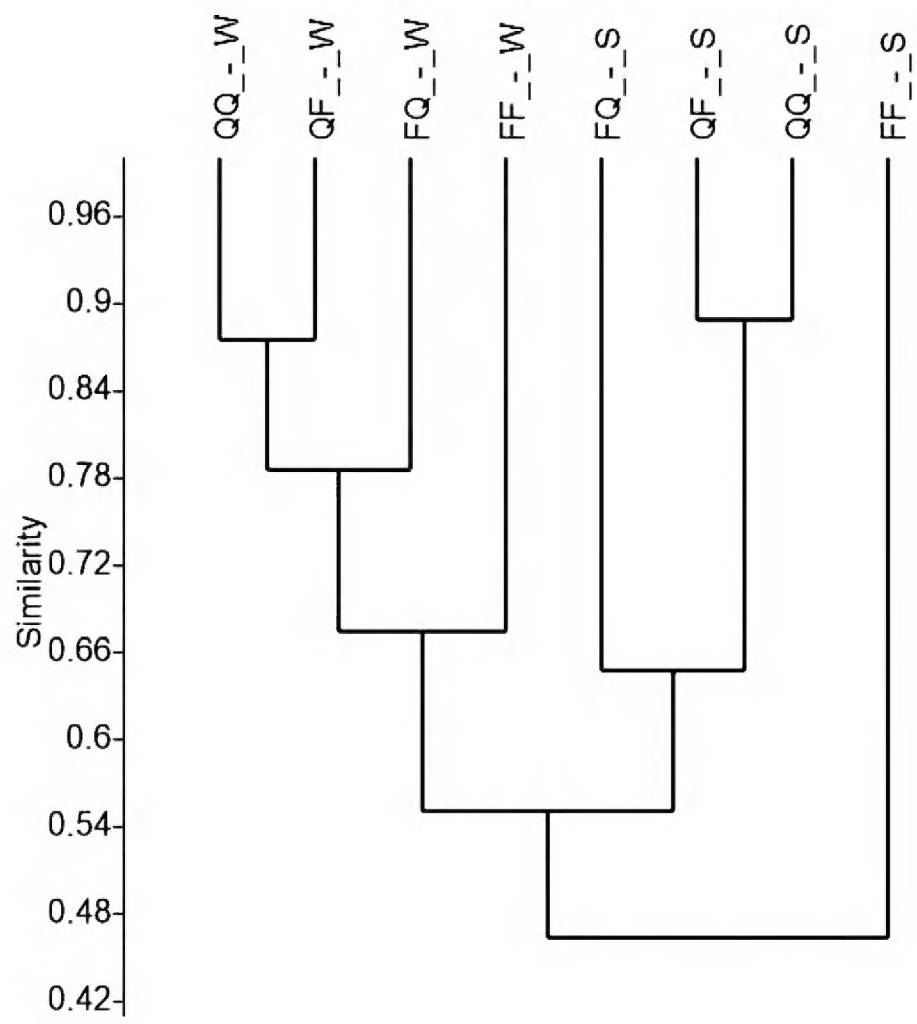

Figure 1. Cluster dendrogram indicating microarthropod faunal similarities (based on Sorensen's distance) (Explanations to the acronyms see in methodology section).

Table 2. Biodiversity indices in litterbags with different litter type (Explanations to the acronyms see in methodology section).

Diversity indices	QQ-S	QF-S	FQ-S	FF-S	QQ-W	QF-W	FQ-W	FF-W
Taxa_S	35	10	23	21	19	45	37	36
Individuals	105	26	108	79	45	167	377	165
Dominance_D	0.07501	0.2663	0.09945	0.1601	0.08938	0.05791	0.145	0.0923
Simpson_1-D	0.925	0.7337	0.9005	0.8399	0.9106	0.9421	0.855	0.9077
Shannon_H	2.99	1.666	2.661	2.386	2.585	3.258	2.381	2.811
Evenness_e^H/S	0.6026	0.5881	0.6222	0.5436	0.8291	0.6343	0.3279	0.5039

individuals/litterbag) (F = 4.447, *p* = 0.043) (Fig. 2A, Table 3). Seasonal differences in abundance were much more apparent: 20 ± 15 individuals/litterbag were recorded in summer, while 80 ± 40 individuals/litterbag were recorded in winter (F = 51.4, p < 0.0001) (Fig. 2C, Table 3).

There were no significant differences in abundance between habitat type and leaf type, or between habitat and season. However, significant differences were recorded between leaf type and season (F = 1.169, *p* = 0.029) and within the Habitat × Leaf × Season interaction (F = 5.188, *p* = 0.03; Table 3). A significant difference in abundance was recorded between QQ litterbags in summer and winter, as well as between QQ and QF microarthropods during both sampling events. Under the beech trees, a difference in abundance was observed between FF litterbags in summer and winter (Fig. 3A).

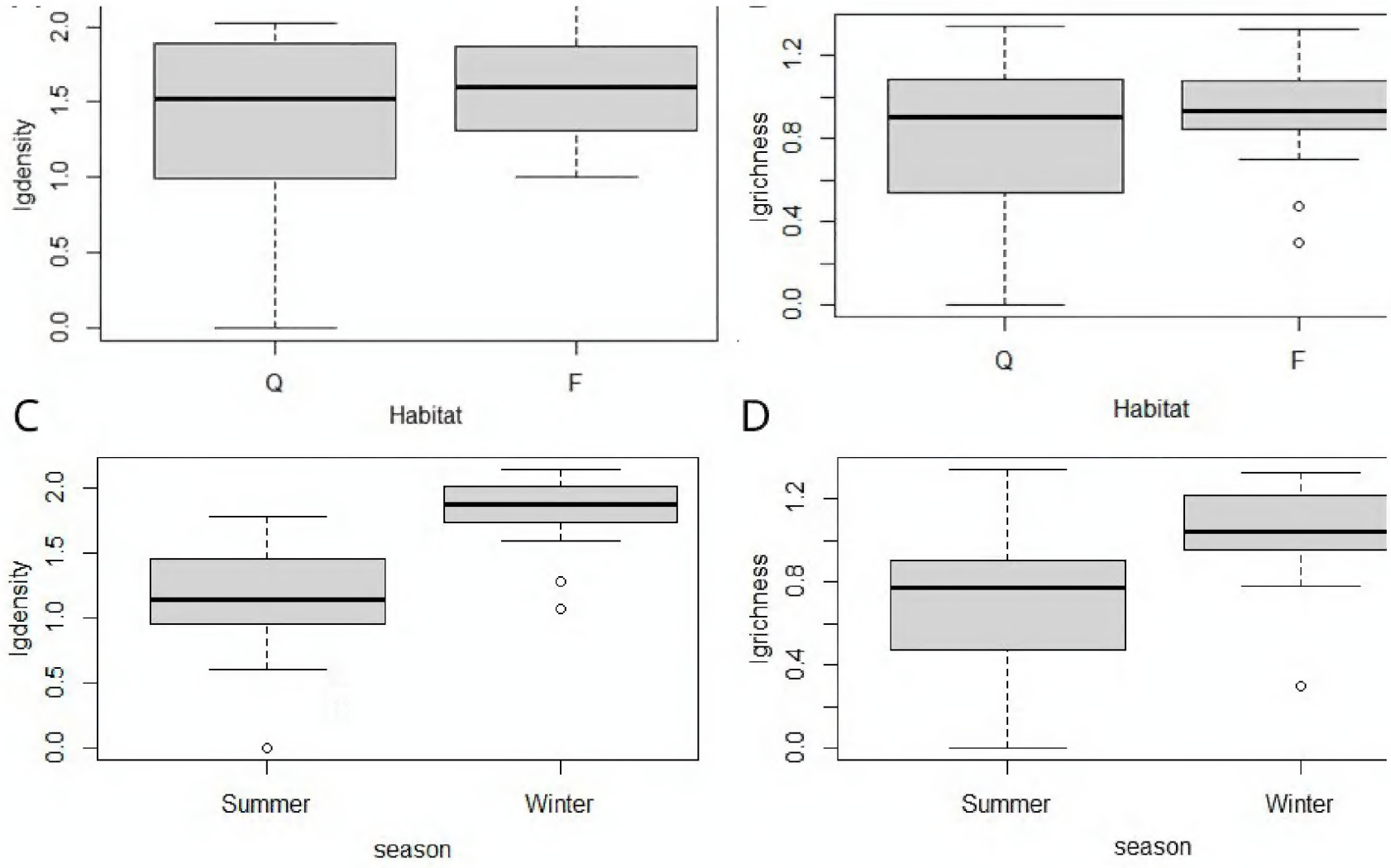

Figure 2. Average abundance (inds/litterbag) (A) and species richness (sp/litterbag) (B) of microarthropods under the oak (Q) and beech (F) trees; Average abundance (inds/litterbag) (C) and species richness (sp/litterbag) (D) of microarthropods after six (summer) and twelve (winter) months from litterbag placement.

Table 3. F-value table of the effect of habitat (oak (Q) vs beech (F) stands), litter type (oak (Q) vs beech (F) leaves) and season (summer (S) vs winter (W)) on abundance and species number of microarthropods (0 '***', 0.001 '**', 0.01 '*', 0.05 '.' explanations of acronyms see in methodology section).

	Abundance					Species richness				
	DF	**Sum Sq**	**Mean Sq**	**F value**	**Pr>(F)**	**DF**	**Sum Sq**	**Mean Sq**	**F value**	**Pr>(F)**
Habitat	1	0.408	0.408	4.447	0.043 *	1	0.195	0.195	2.973	0.095
Leaves	1	0.134	0.134	1.463	0.236	1	0.179	0.179	2.739	0.108
Season	1	4.709	4.709	51.369	<0.0001 ***	1	0.295	0.295	19.757	0.0001 ***
Habitat:Leaves	1	0.094	0.094	1.032	0.318	1	0.002	0.002	0.023	0.88
Habitat:Season	1	0.315	0.315	1.169	0.073	1	0.082	0.082	1.251	0.272
Leaves:Season	1	0.107	0.107	1.169	0.029 *	1	0.411	0.411	6.277	0.018 *
Habitat:Leaves:Season	1	0.475	0.475	5.188	0.03 *	1	0.346	0.346	5.285	0.028 *

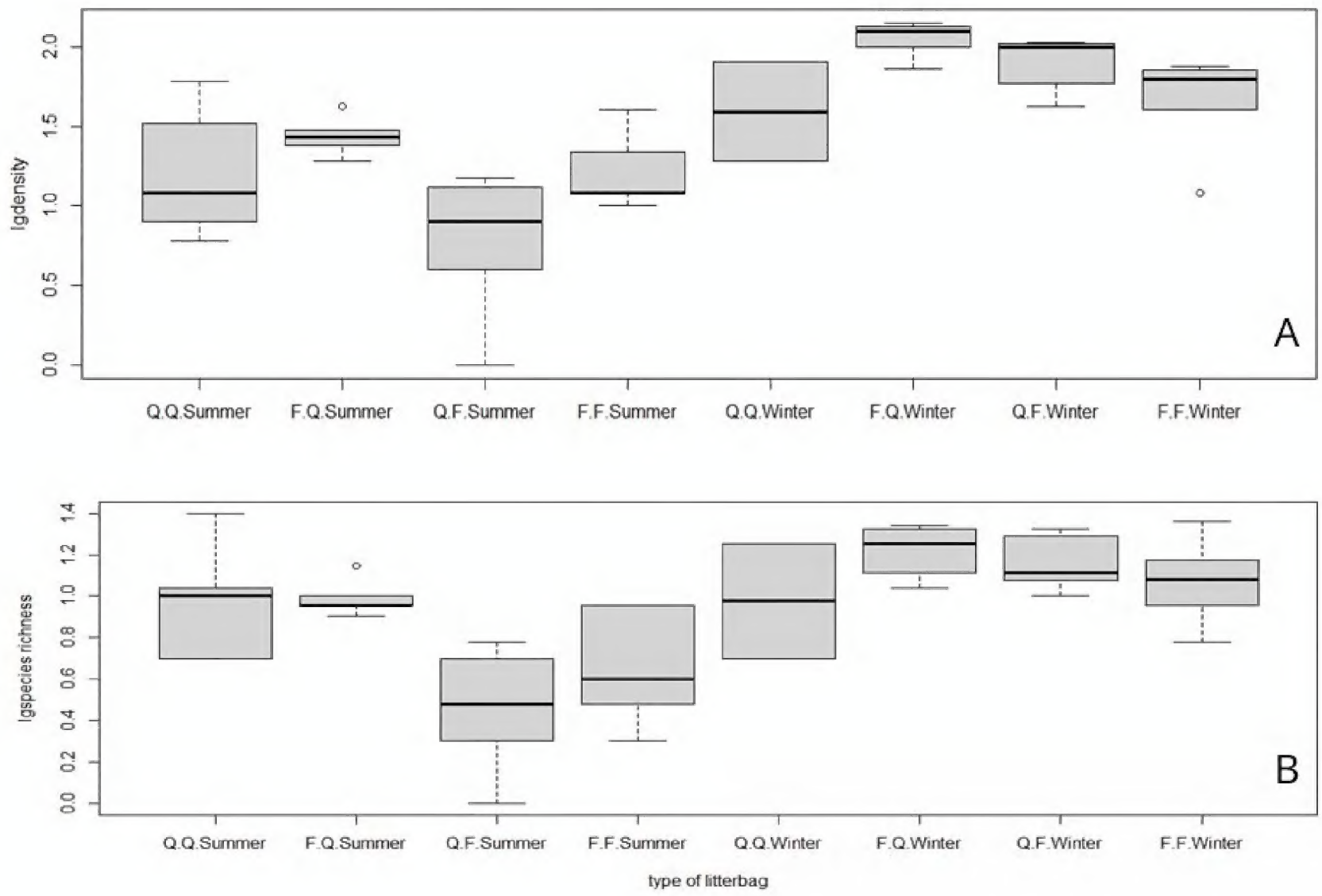

Figure 3. A: Average density (inds/litterbag) and **B**: species richness (sp/litterbag) of microarthropods in studied litterbags (explanations to the acronyms see in methodology section. Summer indicates on the litterbags collected in June, while Winter indicates on the litterbags collected in December).

Microarthropod species richness in litterbags

The average number of species under oak was 8.6 ± 6 species/litterbag, while it was 9.9 ± 5.5 species/litterbag under beech (F = 2.973, p = 0.095) (Fig. 2B, Table 3). Similar to abundance, the overall seasonal difference in species number was clear, with 12.2 ± 5.2 species/litterbag in summer and 6.4 ± 4.9 species/litterbag in winter (F = 19.757, p = 0.0001) (Fig. 2D, Table 3).

No significant difference in species number was found between habitat type and leaf type or between habitat and season. However, significant differences were recorded between leaf type and season (F = 6.277, p = 0.018) and within the Habitat × Leaf × Season interaction (F = 5.285, p = 0.028; Table 3). A difference in species richness was recorded between QQ litterbags in summer and winter, and between QQ and QF during both sampling events. Under beech, a difference in species number was shown in FF litterbags between summer and winter, while no such difference existed between FF and FQ litterbags in either season (Fig. 3B).

Distribution of microarthropods by feeding mode

In June, primary decomposers predominated in all microhabitats. Fungivores were the second most dominant group, while predators were in the minority; lichen feeders were represented only in QQ litterbags. By the end of the exper-

iment in December, the percentage share of secondary decomposers and fungal feeders had declined, while the proportion of predators and lichen feeders had increased.

Change of Litter Mass

A significant decline in litter mass was observed in all litterbag types (QQ, QF, FF, FQ) during the first six months ($p < 0.02$). However, the process diverged during the second six-month period. Between summer and winter, no significant decline in litter mass was observed in QQ litterbags, while a significant decline continued in the other combinations (QF: $p < 0.03$; FQ: $p < 0.01$; FF: $p < 0.01$; $df = 4$) (Fig. 4).

After the first six months, the remaining dry mass was 44.2% in QQ, 38.5% in QF, 41.7% in FQ, and 39.9% in FF. During the final six months, mass decline slowed: 43.5% of the initial dry mass remained in QQ, 33.5% in QF, 36.6% in FQ, and 29.8% in FF (Fig. 4)

Discussion

Among the microarthropods identified in this study, oribatid mites dominated all litterbags in both species composition and number of individuals. The succession of microarthropods during the process of litter decay was evident by the increasing number of taxa and individuals between the first and second sampling events. During this period, the overall number of Oribatida

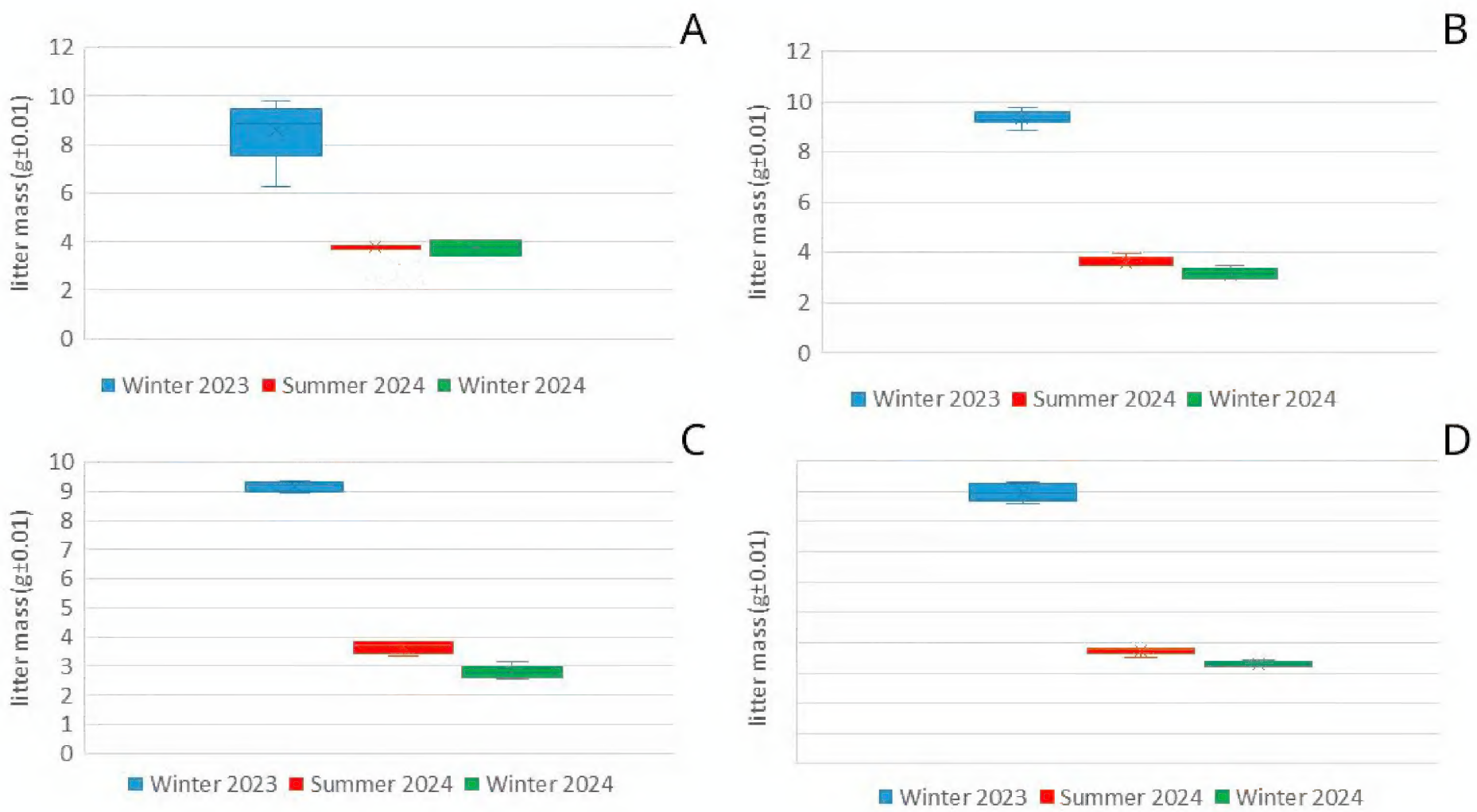

Figure 4. Change of the litter dry mass (g±0.01) during the experiment in **A**: QQ, **B**: QF, **C**: FF and **D**: FQ litterbags (Explanations to the acronyms see in methodology section).

increased from 298 to 480 individuals, Mesostigmata from 19 to 274, and Collembola from 42 to 614. The increased biodiversity index and decreased evenness, associated with higher overall dominance in winter compared to summer, indicate an increase in certain types of resources that promote the dominance of specific taxa. Collembolans are known to be successful colonizers of litterbags; along with Oribatida, they increase their dominance as the litter decomposition process progresses (Miko 1995; Fujii and Takeda 2017). The increasing numbers of Mesostigmata are associated with an increased number of their prey, as true soil-inhabiting Mesostigmata are mostly predators (Coleman et al. 2017).

The community of oribatids changed during the process of litter decomposition. *Gymnodamaeus bicostatus* was present in all litterbags collected in June but was completely absent from litterbags in winter. Although the feeding preferences of this species are unknown, it is known to prefer moss- and lichen-dominated habitats and is frequently found on tree trunks (Weigmann 2006). Therefore, we can assume that it feeds on fresh or early-stage decaying plant tissue and is not adapted to the materials found in the later stages of decay, where persistent compounds are broken down by the enzymatic actions of fungi (Berg and McClaugherty 2008).

Cepheus dentatus was another species found in early decomposition stages and absent in winter in both oak- and beech-filled litterbags. This species is known as a primary decomposer and fungal feeder (Maraun et al. 2023); therefore, its absence from later successional stages is surprising. *Eremaeus hepaticus*, *Eubelba dubinini*, *Phthiracarus longulus*, and *Suctobelbella duplex* were absent from litterbags sampled in June, while they were frequent and numerous in winter. These species are typical inhabitants of forest soils and litter. Representatives of Suctobelbidae are known to be scavengers and predators, while Phthiracaridae are mostly primary decomposers (Schneider et al. 2004), and the majority of Eremaeidae are decomposers and fungal feeders (Maraun et al. 2023).

In contrast, *Ceratoppia bipilis*, which shares the same feeding guild (decomposer and fungivore; Maraun et al. 2023), constantly dominated all types of litterbags throughout the entire experiment. The clear separation of the studied microarthropod fauna by season provides further proof of the involvement of different taxa in decomposition processes (Miko 1995; Skubala and Maslak 2010; Hågvar and Steen 2013). The presence of more diverse and numerous soil animals at later stages of decay is further supported by our investigation, which showed higher overall abundance and species richness at the final stage of the experiment. Seasonal differences in microarthropod composition are also affected by seasonal differences in moisture and temperature, which lead to the accumulation of different feeding resources (Cordes et al. 2022).

The type of habitat was not a significant factor in shaping the soil microarthropod community. Species that showed preferences for either oak or beech habitats were usually not numerous and were represented by only one or two individuals.

The succession of microarthropods in the litterbags is demonstrated by the trophic composition of species, with an increased dominance of predatory taxa and the appearance of lichen-feeding species. In fact, representatives

of predatory Mesostigmata, such as *Discourella* sp. and *Trachytes arcuatus*, only appeared in litterbags collected in winter, followed by lower numbers of Uropodina, which include both predatory and fungivorous species (Coleman et al. 2017). The presence of lichens at later stages of decomposition further supports colonization by microarthropods by releasing the nutrients and promote the abundance of soil fauna participating in litter breakdown (Lang et al. 2009; Concostrina-Zubiri et al. 2021; Jegede et al. 2023). Lichen-feeding oribatids were present in small numbers: *Cymbaeremaeus cymba* was only found in winter, and *Mycobates parmeliae* was more frequent in winter, with only one individual of the latter species being found during the first sampling event. The increased dominance of fungivorous mites is also not surprising, considering the colonization of fungi in decomposing litter (Coleman et al. 2017).

The significant difference in abundance and species numbers between microarthropods in litterbags with oak leaves (as opposed to beech leaves) under oak trees supports our assumption that the well-established community under oak trees is adapted to oak litter decay. Surprisingly, no significant difference was observed between the litterbags under the beech stands. This may be the result of our study site represented by the mixed forest dominated by oak, with beech being restricted to the upper edge of the forest slope. The formation of distinct oribatid communities in specific habitats is often attributed to their low dispersal abilities (Cordes et al. 2022), but one would expect the side-by-side placement of litterbags filled with oak or beech leaves to bypass this limitation.

The experiment showed a continuous decline of beech litter mass under both oak and beech stands. However, this was not the case with oak litter; the oak leaves maintained their shape and structure throughout the whole experiment, whereas the beech leaves were almost unrecognizable by the end of the study. The data show that the process of mass loss slowed down between the first and second sampling events in litterbags with oak litter placed under oak trees, but continued to decline in oak litterbags placed under beech trees. Beech litter is known to decompose faster than that of many other trees (Jacob et al. 2010), while oak litter shows slow decomposition rates compared to other deciduous leaf litter (Miko 1995; Pardo et al. 1997). One suggested reason for this difference is the less dense canopy of oak compared to beech forests (Miko 1995). We suggest another reason for the faster mass decline of beech litter may be the structural differences between oak and beech leaves. Studies show that the structural thickness and density of oak leaves are higher than those of beech (Poorter et al. 2009; Aranda et al. 2004). Moreover, oak leaves have been shown to have a thicker adaxial cuticle and epidermal cell wall compared to beech leaves (Bahamonde et al. 2018); this could make oak leaves less permeable to microorganisms, resulting in a slower decomposition process.

In contrast to our findings, Lorenz et al. (2004) observed different results in their litterbag experiment in the Mannheim-Käfertal Forest after 0.5 and two years of decomposition. The authors report a greater dry mass decline for oak than for the beech litter. This differing pattern may be explained by a higher C/N ratio and higher tannin content in fresh beech litter compared to oak leaves, indicating a lower quality of beech litter in terms of decay in that specific environment.

Conclusions

- Microarthropods successfully colonize defaunated litterbags and contribute to the decay of their contents.
- Microarthropod fauna became more abundant and species-rich at later stages of litter decay, showing a progressive succession of microfauna and indicating more diverse feeding resources.
- The microarthropod community was shown to be adapted to the dominant type of litter present (oak leaves in this case), while more time was needed for it to adapt to an alternative type of litter (beech leaves).
- Different microarthropod communities participate in litter decomposition at early and later stages of decay.
- The trophic composition of the microarthropod fauna is more diverse at the late stage of litter decomposition.
- Beech litter shows a faster mass loss than oak litter.

Acknowledgements

The authors thank to Dr. Levan Mumladze for help in experiment design. We also thank the reviewers of the manuscript for their valuable comments.

Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

Funding

Shota Rustaveli National Science Foundation of Georgia (SRNSFG) [grant number FR-24-1553].

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Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

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